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ABSTRACT

This paper relates the concept of computer-driven multimedia to the National Aeronautics and Space Administration (NASA) Scientific and Technical Information Program (STIP). Multimedia is defined here as computer integration and output of text, animation, audio, video, and graphics. Multimedia is the stage of computer-based information that allows access to experience. This paper draws in the concepts of hypermedia, intermedia, interactive multimedia, hypertext, imaging, cyberspace, and virtual reality. Examples of these technology developments are given for NASA, private industry, and academia. Examples of concurrent technology developments and implementations are given to show how these technologies, along with multimedia, have put us at the threshold of the 21st century. The STIP sees multimedia as an opportunity for revolutionizing the way scientific and technical information is managed. There is a vast opportunity for looking at multimedia applications, assessing their relevance to the handling and processing of scientific and technical information in the NASA research and development community, and developing multimedia implementations for doing so. (Contains 24 references.) (TMK)

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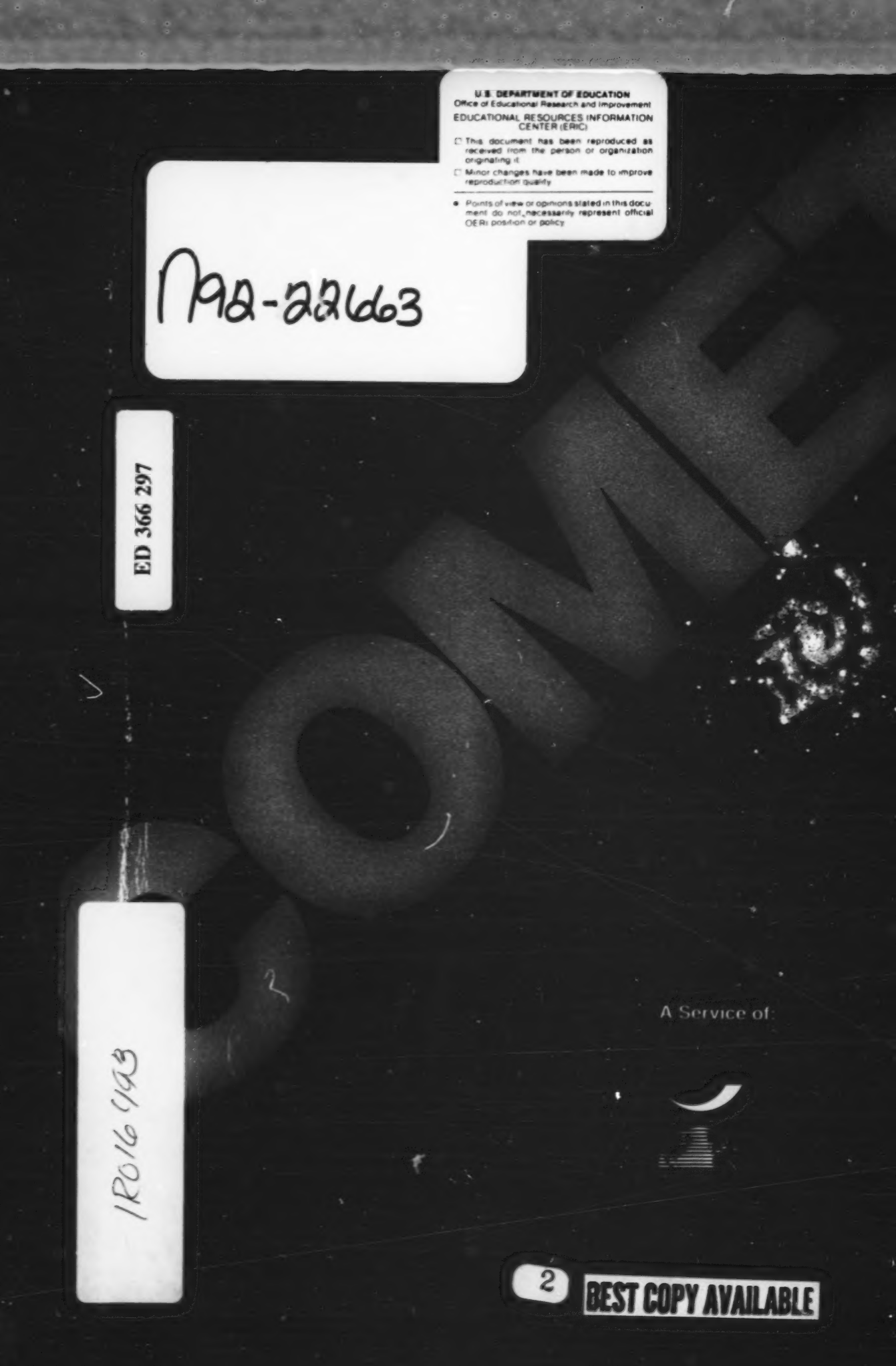

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Quo Vadimus? The 21st Century and Multimedia

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Washington, DC

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Scientific and Technical Information Program
Washington, DC 1991

QUO VADIMUS? THE 21ST CENTURY AND MULTIMEDIA

"The computer display screen will be mankind's new home."
- Ted Nelson, *Dream Machines, The Flip Side of Computer Lib*, Microsoft Press, 1974, 1987.

Allan D. Kuhn
NASA Scientific and Technical Information Program

November 1991

In this year of 1991, we are in the 21st Century.

Advances in adaptation of technology are historically accentuated, benchmarked, and propelled forward, as distasteful as it is, by wars. A prime example is the 19th Century American Civil War. It is commonly accepted, in historical context, that this war was the first war of the 20th Century simply through its rapid technology developments in weapons and weapons support systems. The repeating carbine, Gatling gun, iron clads, telegraph, *i.e.*, electric communications, submarines, balloons, *i.e.*, lighter-than-air craft, railroad transportation, weapons metallurgy and ballistics, photography, *i.e.*, imaging technologies, are examples of the Civil War technology adaptations that influenced the thrusts of warfare for most of the 20th Century. Peacetime growth of technologies was in turn propelled forward by the wartime developments, e.g., expansion of electricity-driven communications, image presentation, railroad and automotive transportation, distribution systems for commodities, manufacturing technologies, foodstuffs preservation, aircraft developments, and on and on.

In our common experience of today, the Persian Gulf War of January, 1991, because of its unprecedented technology, is the first war of the 21st Century. It is the benchmark war that has kicked us across the threshold to the 21st Century. Up until this war, a plethora of reports, books, and commentaries coming out of the Federal government, private industry, academia, and the press constantly questioned the world position of the United States in its predominance in technology. The technology used in the Persian Gulf War, successfully proven under fire, confirms U.S. technology prowess.

NASA had a major part in the success of American technology in the Persian Gulf War, as indicated in its summer 1991 issue of *NASA Update - State and Local Newsletter*.* A brief article titled "Advanced Technology Hastens Victory in Gulf Conflict" (p. 3), states:

> *Victory in the Persian Gulf conflict was a triumph of advanced technologies. Many of those technologies had roots in aeronautics and space research and development that NASA and the U.S.military establishment have conducted or sponsored over the years.*

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* NASA Office of External Relations, Defense and Intergovernmental Relations Division. *NASA Update: State and Local Newsletter* 5, 1 (1991).

. . . Some of the types of systems that contributed to the speed with which the war was terminated and that were possible only because of advanced technology development by NASA and the military are:

- *Visual and infrared imaging systems and the related systems for interpreting and presenting information collected by the imaging systems. Those systems contributed significantly to the accuracy achieved in reconnaissance, surveillance, and targeting.*

- *Satellite-based communications systems that provide transmissions to and from remote locations. Essential to the coordinated, effective operations that speedily provided victory, they had the side effect of turning the conflict into a "media event."*

- *Computers that are small, rugged, and portable. These ubiquitous marvels of the space age made possible any number of improvements in planning and execution not previously possible.*

- *Propulsion and guidance systems, which enable "smart munitions" to attack defended targets with devastating accuracy and the Patriot missile to become the 'Scud buster."*

The "bottom line" for advanced technology in the U.S. arsenal is the speed with which hostilities were successfully concluded and the avoidance of unnecessary injuries and deaths of U.S. personnel.

A good part of that technology involved machines making decisions and conveying information based on those decisions to people, *vis-à-vis* people making decisions based on raw data provided by machines. This is the new environment, not only for warfare, but now also for peacetime. In the first NASA STIP *Quo Vadimus* document of May 1991 (BLAD91), the author, Mr. Walter Blados states:

...we find ourselves living in a new environment... . New relationships and new opportunities are resulting from the increased availability of information and the stimulation and expanding opportunities it brings. There will be new individual and organizational relationships, new methods of doing our work, and new environments in which we will carry out our work.

A part of our 21st Century environment and its "new methods of doing our work" is computer-driven *multimedia*, an ever expanding means of conveying information to people.

WHAT IS MULTIMEDIA?

Multimedia is computer integration and output of text, animation, audio, video, and graphics.

You sit at your computer screen and watch and hear the action. You choose what you want to take place. You listen to what someone has to say as you watch him speak; you hear music as background to the multimedia presentation; with scientific experiments and studies you witness the experiment and its attendant results in all their forms - visual and auctorial; you examine changes, shapes, and forms based on those changes you yourself select.

A NASA engineer at Langley Research Center reviews a wind tunnel test. The engineer inserts an optical disc into a drive, and observes the actual test as it took place. This includes sound and visuals, in addition to the manuals needed to run both the wind tunnel multimedia system, and the actual wind tunnel system itself. An embedded advisory system not only stores experts' knowledge and experiences, but can be added to by the engineer. The engineer proceeds with visualizations of computerized model data from the test -- pressure distribution in both actual test data and computer simulation data. The test platform is re-

oriented on the screen to see the effects of the test from differing vantage points. He changes test factors to see what changes would take place in the test results. Both sound and color, in addition to the video representation, convey data to the engineer. The engineer, in reviewing this earlier test, makes decisions on how to proceed with a new test.

A NASA employee, after a long day's work, goes home - and to relax, turns on his machine. The machine has downloaded the day's soap operas. In fast-forwarding through the programs, he selects clips, and stores them separately on the hard disk. In reviewing the clips, he further selects portions of them, and then joins the clips into a media document that he is creating. The media document is a "paper" he is composing for his Doctoral thesis on *The Effect of Human Dramatization of Intersocietal Problems of People as Portrayed by Cable Television Services.* The thesis will exposit the creator's premises through contextual visual and auditory information; text will be minimal, and that probably will be spoken by the creator, likely as voice-overs, less in lecture form. The creator will also create interactive elements in the thesis, for the referee/viewers to explore and compare variances to the premises.

A medical doctor assistant on a NASA space station is faced with a crewman accident emergency, a sliced off thumb, and needs to review texts and procedures before performing a needed reparative operation. There are several progressive multimedia scenarios that can be imagined, all based on technologies available and emerging today.

- Scenario A - The doctor assistant refers to his onboard, miniaturized medical reference system, comprised of the major medical references in U.S. practice. This system is replete with page images of the original texts, with the original drawings and photographic illustrations, including their color. The texts are rapidly searchable ("hypertext") simultaneously, and therefore easy to cross-correlate.

There is also voice and motion picture instruction on medical procedures. After conferring with the system and with "medical emergency central" -- Kennedy? Johnson? -- the doctor assistant proceeds with the reparative procedure. This may take several hours.

- Scenario B - In conjunction with the above, operation is closely monitored by earth-based medical staff following an analysis of televised images of the injury condition, with an automated program run-through of the reparative procedure based on those images and virtual reality technology, and retransmitted to the doctor assistant on the space station. All this happens in less than an hour.

- Scenario C - Again in conjunction with all the above, all images of the situation are fed into a robotic cyberspace technology system - the system in processing the images and medical programs, monitored by the space station doctor assistant and the earth-based medical staff, will conclude the needed procedures for the operation and perform it. Cyberspace technology "is a type of interaction simulation which includes humans as necessary components. A cybernetic simulation is a dynamic model of a world filled with objects that exhibit lessor or greater degrees of intelligence." [WALS91] With this combination of imaging-cyberspace-robotic technologies, the reparative processes take place within ten minutes.

INCREDIBLE, YOU SAY?

Multimedia is here today. All the media elements involved in the above scenarios are alive and well -- "cyberspace" technology, for example, has been around

and in development since the 1960s. Listen to what major movers in the computer industry are saying --

> *"Multimedia will change the world in the 1990s as personal computers did in the 1980s."* - John Scully, Apple
>
> *"Multimedia will be bigger than everything we do today."* - Bill Gates, Microsoft
>
> *"We're going to put a computer in every home...with multimedia."* - James Cannavino, IBM

Do you get the feeling that there is something highly evolutionary going on in the realm of information? I think the very basic idea of multimedia is that it is the stage in computer and information technologies that will give us **access to experience**. This may be seen more easily within the context of the stages of information access:

- 1 Access to Data *Numeric, calculatory*
- 2 Access to Information *Textual results* via *coordination of terms*
- 3 Access to Knowledge *Reviewing and reformatting electronic text*
- 4 Access to Experience *Cognitive and sensory processing*

Each of these access capabilities have expanding sets of tools underlying them to provide the capabilities, with each access capability folding into the next level to give greater expanded access.

It is generally accepted that the seminal article setting down the ideas of what are now multimedia processes was Vannevar Bush's "As We May Think," appearing in *Atlantic Monthly*,* July 1945. In this article Bush, in giving form to ideas *possible at that time*, suggested creating linkages between documents, which in turn would be brought to a screen as rapidly as possible according to those linkages. In his time, he was thinking about microfilm images. For our time, read automated text, pictures, movement, and sound, all documents in our expanded concepts.

WHAT'S HAPPENING TODAY?

The forces of the market place are the best indicators for the use and success of multimedia programs. The following uses of private sector multimedia, shown here as examples of commercial multimedia applications, has been compiled and provided by Mr. Thomas A. Wheeler of Multimedia Design Corporation [WHEE91]:

- Northern Telecom is using multimedia to train their 20,000 employees at about 1/10th the cost of traditional training methods. (MacWeek article).

- American Airlines has a multimedia project on the boards to provide initial and refresher training for 50,000 employees. They expect "50% reduction in training time per employee", "reducing 300 hours of lessons to 152" hours (MacWeek, August 14, 1990).

- GTE North, Inc., is using multimedia to teach workers how to fix telephone cables. "The retention rate has to be three or four times higher than lectures and pencil testing" (Business Week, October 9, 1989).

- General Motors Buick Division has developed a multimedia presentation that allows prospective customers to browse an electronic brochure, on a PC, through descriptions and animated pictures of cars, complete with engine sounds. The marketplace results of such a brochure were that 12% of those who bought cars after receiving the electronic brochure ended up picking Buick - this was about **double** its usual market share (Business Week, October 9, 1989). The electronic brochure includes car models, model

* Vannevar Bush. "As We May Think." *Atlantic Monthly* 176, 1 (July 1945); 101-8.

options like color, wheels and styling, and spreadsheet operations that calculate payments and make price comparisons with competitor cars. The brochure is interactive with the customer, and consequently the customer spends more time with that than with a handful of paper brochures.

• Steelcase Inc. uses an electronic brochure to launch a new line of office furniture. Customers "can get to information more conveniently than by pawing through pages of [paper] brochures" (Business Week, October 9, 1989). Customers and designers move 3D renderings about a computer screen to see how different furniture looks in a specific room, while a voice provides product details against a musical background.

• The American Heart Association is distributing a set of digitized interactive lessons to medical schools on how to manage blood cholesterol levels. The program gives students an audiovisual rundown detailing how cholesterol moves through the blood and liver.

What other commercial effects does private sector multimedia have in addition to those noted above? A study done by Duthie and Associates [WHEE91] has compared the costs of different training methods, based on cost per student for 1,000 students. Their cost figure study results are:

Classroom	$8,900
Videotape	482
Cassette	459
Workbook	409
Videodisc	403
Computer-based training	226
Interactive Multimedia	***132***

TERMINOLOGY, OR, CONFUSION *á go go*

"Multimedia" and "Interactive Multimedia" are now the catch phrases in the market place. There are several other terms, though, that are also used to designate these processes, or are incorporated in the multimedia processes. These terms are "Hypermedia," "Hypertext," "Intermedia," and "Imaging." In the interest of some standard acceptance of the terms, I would like to pick up the following explanation from one of the papers in the book, *Learning with Interactive Multimedia* [AMBR90]:

> *A note about terminology: As is often the case in new fields, no consensus exists in the multimedia field about what various terms mean or what to call certain items that clearly need names. "Multimedia," "hypermedia," and "intermedia" are often used interchangeably to describe the same thing. In this* [paper], *I use the term "multimedia" to describe any software using the four essential communications media -- text, audio, images, and logic -- whether on a media computer or an analog video-computer hybrid. I use the term "hypermedia" to describe a subset of multimedia that has "hyper" characteristics: various modules linked in a nonhierarchical, nonlinear structure. . . .* [OSBO90]

Multimedia and Hypermedia at this point are nearly interchangeable; any difference may be particular to an application and in the nuance. Interactive multimedia refers to the viewer making selections in the multimedia program that causes the program to go off in another direction. Intermedia seems to be used very little any longer.

"Hypertext," in the words of the term's originator, Theodore "Ted" Nelson, means "non-sequential writing. . . . Ordinary writing is sequential . . . But the structures of ideas are not sequential. They tie together every which way." [NELS87] Mr. Nelson, who coined the term in 1965, means here a system of computer-supported, nonsequential information processing, primarily, of course, of text. One selects a term or

phrase, and sees how the positions of the term relate throughout a document or set of documents. The underlying principle is "the ability to create computer-supported links or cross-references permitting rapid, easy movement" among related parts of information in the text or document set [KAYE91].

"Imaging" is a widely used catch phrase throughout the market place. Currently there are two basic areas involving imaging technologies: business imaging and technical imaging. Imaging in the business context refers primarily to automating business processes and activities. This means basically forms and correspondence, but also extensively including any images and graphics that support the business activities. The forms and correspondence appear on the screen "imaged" as they appear in paper form. When connected to fax capabilities, company forms and correspondence, if not input into a receptor imaging system, fax out on paper in the originating company's correspondence letterhead and format. Technical imaging concerns computer-stored images to support scientific and engineering activities. It is comprised of everything ranging from satellite-originated digital data images of earth and space, and remotely-sensed data, to scanned-in maps, X-ray images, magnetic resonance images (MRIs), microscopic images, you name it.

As a consequence of the multiplicity of terms, in the various examples following, "Hypermedia" may be correlated to "Multimedia"; "Hypertext" and "Intermedia" may be considered as features or effects that are incorporated in multimedia/hypermedia processes.

So . . .

WHAT'S HAPPENING IN NASA?

A review of materials cited in the NASA/RECON information system shows extensive interests across the whole of NASA. There are a multitude of multimedia/hypermedia developments going on in the transition from traditional linear information retrieval to actual information viewing. This is happening in what has been termed the *multidimensional information space* [SEPEC90]. We already see from above how this is changing the way we store, retrieve, and use information. Hyper-branching applications are being experimented with throughout the whole of the government, academia, and private industry. The following are but a few examples representative of what is taking place in NASA. Included is an example of Hypertext application, with the view of showing such activity as a component of multimedia support. The descriptive information of the activities below is extensively *verbatim* from the papers cited [KAYE91].

The Experiment Documentation Information System (EDIS). EDIS is being developed by Houston Applied Logic, Houston, Texas, for the NASA Life Sciences Project Division at NASA Johnson Space Center, Houston, Texas. It is a system designed to produce and control the Life Sciences Experiment Document (ED) containing large amounts of text in combination with tables and graphs of mathematical and scientific data, making use of hypertext concepts through Macintosh HyperCard. The ED defines all functional objectives, inflight equipment, consumables, measurements, ground support, and test sessions, along with the expected results of the experiments. The ED consists of 16 chapters plus appendices. There is a fixed, or boilerplate text in some sections that applies to any Life Sciences experiment and reference table formats concerning experiment-specific text and mathematical/scientific data. Other sections contain experiment data tailored for each experiment. The EDIS is foreseen as being the first step in the automation of the process required for defining complete packages of Life Sciences experiments for the Shuttle missions [MOOR90].

Life Sciences Interactive Information Recall (LSIIR). This is a study in hypermedia applications, being done by GE Government Services, Houston, Texas, for the Life Sciences Project Division, Johnson Space Center. LSIIR, through interactive media technologies, provides online information aids as a "job performance assistance." The technologies are integrated into a computer desktop workstation environment with which mission or payload specialist, the scientist, the engineer, and support or administrative people are familiar. The LSIIR is foreseen as providing assistance in Life Sciences Project missions and activities such as development and testing, science monitoring, technical lab activities, and mission testing. The system uses Mac SEs for running integrated applications of HyperCard, MacRecorder Sound System, MacDraw, MacPaint, Canvas, and MacroMind Director. MacroMind Director enhances graphics display and animation. Clip art and scanned photos are part of the system's information base. The system serves as a "trainer" or simulator. It provides the user with different sets of information to change variables during an exercise, or make alterations to procedures and configurations. LSIIR has passed its proof of concept stage, and is envisioned as an online system for electronic documentation and information, and electronic training and review in all areas of the NASA Life Sciences Project activity [CHRIS90].

Knowledge Base Browser (KBB). Currently under development at the NASA Johnson Space Center is a hypermedia system for browsing CLIPS knowledge bases. CLIPS is C Language Integrated Production System, an expert system shell used in this case to create knowledge base expert systems of rules that control the processes of the Onboard Navigation (ONAV) flight control position at the Mission Control Center (MCC). These expert systems will support the ascent, rendezvous, and deorbit/landing phases of a Shuttle mission. The KBB, as a component program of the MCC, serves to assist in the verification of the rule bases of the various expert systems, and to augment the training of the flight controllers. When complete, the KBB will verify and browse the CLIPS rule bases. This system, which in the view of its creators is a hypermedia system, will include the capabilities of automatic creation of links based on the CLIPS rule structure, querying the rules and saving the results as a collection, and browsing the rule bases either sequentially or by using the links and collections [POCK90].

The Space Station Freedom User Interface Language (SSF UIL). SSF UIL is in development at the Space Operations and Information Systems Division of the Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder. It is designed for use by the astronauts, ground controllers, scientific investigators, and hardware/software engineers who will test and operate the systems and payloads aboard the space station. The IUL is object-oriented, English-like, supplements the graphical user interface to systems and payloads by providing command line entry, and will be used to write test and operations procedures. Hypertext is used to provide links between users of code (statements, steps, procedures, *etc.*) and associated annotation and documentation, linking code to object information, and linking steps within a procedure [DAVI90].

Artificially Intelligent Graphical Entity Relation Modeler (AiGerm). AiGerm is a relational database query and programming language frontend for Germ (Graphical Entity Relational Modeling) system. These systems are being developed by Microelectronics and Compute Technology Corporation, Software Technology Program (MCC/STP), Austin, Texas. There are three versions of AiGerm in use: Quintus Prolog, BIMprolog, and MCC's Logical Data Language (LDL). AIGerm is intended as an add-on component of the Germ system to be used for navigating very large networks of

information. harnessing Prolog or LDL's relational database query capabilities. It can also function as an expert system shell for prototyping knowledge-based systems. AiGerm provides an interface between the programming language and Germ. When a user starts up AiGerm, the system builds a knowledge base of currently loaded Germ folio. The knowledge base is a collection of node, link, and aggregate facts. The user queries the database and runs programs that select, create, delete, inspect, and aggregate the nodes and links appearing in the Germ browser. To use AiGerm, the user first starts up Germ and loads the desired hypertext network folio into the Germ browser. In a knowledge base, for example, for each hypertext entity - *i.e.*, node, link, and aggregate - AiGerm asserts a fact (a prolog clause). AiGerm is currently used in MCC/STP's DESIRE (DESign Information REcovery) system to extract information on the design code for software systems. Research staff are experimenting with AiGerm in building IBIS (Issue Based Information Systems) - reasoning and decision support systems for software design and engineering. Rockwell International, an MCC/STP shareholder, uses AiGerm in a simultaneous engineering project. MCC/STP states that users of AiGerm can navigate Germ Networks or develop prototypes of knowledge-based hypermedia systems [HASH90].

Clinical Practice Library of Medicine (CPLM). The CPLM was conceived in 1979 by a team of medical and computer experts from the University of Florida and Kennedy Space Center. Since its onset, the system has evolved from a mainframe-based text database to a microcomputer-based hypermedia system that supports both text and high-resolution medical images. The design changes necessary to expand the system to include sound and animation are now being delineated.

The CPLM system is currently a computerized, rapid-reacting, medical reference system that could be placed aboard a long-term space flight to provide the spacecraft physician with nearly instantaneous access to the most complete medical references on Earth. With this type of support system, the physician could be confident that he was making the right diagnosis. The demonstration CPLM system that is available now runs on an IBM PS2 Model 80 microcomputer with a high resolution 8514A Display and a 1 gigabyte disk drive. The system is programmed in C under Microsoft Windows. The system contains a variety of medical texts including the STI Program's special publication NASA SP-3006, the "Bioastronautics Data Book." The CPLM system is written to allow expansibility to the full capacity of the available storage device. Both traditional and hypermedia access to the information is permitted. Traditional Boolean search methods are enhanced by a parsings dictionary unique to each book that holds current spellings and root word divisions along with a lexicon that provides a book specific list of synonyms and abbreviations that automatically provides alternate search terms to the user. Word and phrase linkage among all documents is provided initially by the University of Florida project team with annotations to be eventually added by the physician end users. The educational capability of the CPLM system may be one of its major benefits in addition to its ability to deliver complex information in a user-friendly fashion.

The University of Florida development team leader stresses that the planned addition of voice activation, animation, and interactive hardware can make the CPLM system function as a fully automated physician's assistant. In a few years a miniaturized hypermedia CPLM system is foreseen as being built into space suits and carried by Earthly physicians in their black bags [GRAM91].

Virtual Interface Environment Workstation (VIEW). VIEW is a NASA development with high visibility, that is based on Virtual Reality technology. Virtual reality is "the

creation of highly interactive, computer-based multimedia environments in which the user becomes a participant with the computer in a 'virtually real' world" [HELS91]. In the words of the founder and first Director of the VIEW Project:*

> *In the Aerospace Human Factors Research Division of NASA's Ames Research Center, an interactive Virtual Interface Environment Workstation (VIEW) has been developed as a new kind of media-based display and control environment that is closely matched to human sensory and cognitive capabilities. The VIEW system provides a virtual auditory and stereoscopic image surrounding that is responsive to inputs from the operator's position, voice and gestures. . . . this variable interface configuration allows an operator to virtually explore a 360-degree synthesized or remotely sensed environment and viscerally interact with the components.*
>
> *The current* [VIEW] *system consists of a wide-angle stereoscopic display unit, glove-like devices for multiple degree-of-freedom tactile input, connected speech recognition technology, gesture tracking devices, 3-D auditory display and speech-synthesis technology, and computer graphic and video image generation equipment.*
>
> *When combined with magnetic head and limb position tracking technology, the head-coupled display presents visual and auditory imagery that appears to completely surround the user in 3-D space. . . .* [FISH91]

* Scott S. Fisher, Project Director, 1985-90, following which he jointly founded Telepresence Research. Mr. Fisher holds an M.S. in Media Technology from MIT. (Source: *Virtual Reality* [HELS91])

ACADEMIC ACTIVITIES: TWO MAJOR EXAMPLES

PROJECT EMPEROR-I. This is a well known hypermedia project, merging microcomputer and videodisc hybrid technologies. It has been ongoing since 1984. It is a major research and development project which demonstrates how new technologies enhance better understanding and appreciation of a subject, in this case Chinese humanities, by delivering a large-scale online (real-time) hypermedia, multi-formatted, and multi-dimensional information simply not possible in sequential-formatted systems. The current hypermedia system includes an interactive information delivery model for providing, at rapid speeds measured in fractions of of a second, requested relevant information in any format - visual, audio, textual - as selected by the viewers at their pace and choice, including at the point of need. The project now includes:

- Two 12 inch NTSC CAV videodiscs, entitled "The First Emperor of China: Qin Shi Huang Di."
- Interactive courseware, at both a lay public and a serious researcher levels. Prototype courses have been developed for Digital Equipment Corporation's IVIS systems and for IBM PC compatibles. Later systems now include the Apple Macintosh Mac IIs.
- Electronic image databases for IBM compatibles and Mac IIs. Further development efforts have taken place with SOPHIATEC, Nice, France, and with the Project Athena of Massachusetts Institute of Technology involving a powerful multimedia image system using DEC's proprietary MUSE software for high-end machines such as DEC's MicroVax and IBM RTs. The EMPEROR-I hypermedia system has also been looked at for use on Sun3s and Sun4s.
- High resolution imaging digitization and electronic imaging has been performed on a Sun3-160 using OASIS software.
- Converting and creating large textual files with images and Chinese characters

using MicroTek's MSF-3000 image scanner and INOVATIC's Readstar II Plus optical character recognition software. Digital textual files are kept in the hard disks, but when the data approaches 400-500 megabytes, CD-ROM can be produced.

This project, housed at Simmons College, Boston, Massachusetts, and aided by many interested resources, both industry and academic, is a masterful development. The goal of the project's director, Professor Ching-chi Chen, is to show that computer power, storage technology, and software are now all available, at affordable cost, to provide the opportunities for innovative experimentation of ideas in education, training, research and development in nearly every subject field [CHEN88, CHEN90].

Intermedia. Brown University's Institute for Research in Information and Scholarship (IRIS), Providence, Rhode Island, has developed a powerful multi-user hypermedia software that allows professors, students, and other knowledge workers to create and follow links between electronic documents for different types. This system is named "Intermedia." This project defines hypermedia as the dynamic linking of data such that related data is easily accessible although the actual pieces of data may be stored in different physical locations. In theory the data can be any type, such as text, graphics, spreadsheets, video, or audio. Intermedia provides a desktop environment similar to that found on the Macintosh. The desktop contains applications (or tools) such as a word processor, a structured graphics editor, a historical timeline editor, a scanned-image view, an animation editor, a videodisc controller, and a viewer that displays and rotates three dimensional models. Users (now termed "viewer" or "authors"), with the tools just enumerated, enter data and link significant items of information together for a contextual viewing of that information.

Because of the extensive differences in the storage sources of the information, the Intermedia development incorporated two new concepts in the handling of the information, the "anchor" and the "proxy." The anchor concerns maintaining consistency across the applications; an anchor is a specific selection of data, a part of a document, with the surrounding information used to understand its significance. When a user follows a link, the document window opens to the size and location on the screen most recently saved, and automatically scrolls to the section that reveals the anchor with its surrounding information. The proxy is an intermediary concept used by the viewer for selecting an anchor in disparate data sources, *e.g.*, text, graphics, sound. The use of the data proxy concept allows the viewer to visualize non-graphical and conceptual media, to have simplicity in linking media, and to extend system applications to related data types [CATL88].

21st CENTURY FUTURES - THEY ARE HERE - OR IF NOT, THEN NOT MORE THAN 10 MINUTES AHEAD OF THE TRUTH

There is so much technology on the boards and coming up that the subject of futures is in itself expansive, much more than just in the imagination. Science fiction in today's terms must be more than outlandish, because a good part of yesterday's sci fi is here. Examples: the following appear in *The Futurist*, September-October 1990, Column: "Tomorrow in brief" --

- A natural appearance prosthesis (*e.g.*, artificial leg) made of carbon fiber and contained in a soft continuous covering gives amputees greater mobility to the extent that they may take part in strenuous activities such as rock climbing, cycling, and squash.

- Customized computers are making more and more inanimate objects into smart appliances, tools, and toys. An exotic example is the "skidometer", a microprocessor embedded in skis to

measure speed and elapsed time on the slope. It is expected that major future growth of microprocessor applications will be in household appliances. Such applications will cause the use of these devices to grow from about 300 million in 1989 to 500 million in 1995.

• A recent OTA report provides recommendations on reducing the tremendous costs of spacecraft. Alternatives suggested are:

Fatsats - spacecraft made of heavier, cheaper materials.

Lightsats - smaller spacecraft with fewer capabilities, thereby costing less to build and launch.

Microspacecraft - small, rugged satellites containing very small instruments, which can be launched several at a time from cannon-like launchers.

• The Paris Transit Authority - RATP - has begun testing a new train it hopes to be the "metro of the year 2000." It is not sectioned off into single cars, but a long, single train, nicknamed "The Boa," allowing its 890 passengers to walk from one end to the other. It is expected to replace all first generation, non-pneumatic trains in the Paris metro system between 1998 and 2010.

• Seiko Epson Co. Ltd. is producing a hand-held device, about the size of a TV remote control, that translates English words into Japanese. You run it across a page; it looks up each word and matches the English words to 30,889 Japanese words. (Product: Epson TRAN PRO-1000.)

• A compact, desktop-size robot arm could help students jot down notes and conduct chemistry experiments. Developed by Systems Control of Middlesborough, England, it can be operated through an IBM-compatible computer and uses standard, pretaught sequences. Students can teach the robot new sequences though the robot's keypad or the computer keyboard.

An item of note, of interest to NASA people, concerns the development of solar sailcraft. In the column "Future scope" of the same issue the following appears:

> *Solar Sailcraft Will Race to Mars - To honor Columbus, racers set sights on a "new world" - Solar sailcraft from six nations will compete in a race to Mars in 1992 to commemorate the 500th anniversary of Christopher Columbus's discovery of the New World. ... The sails, which fly on the flow of photons from the sun, will be of various shapes and sizes ... . Most sails will be made of material that is thinner and lighter than plastic food wrap. Folded into small canisters, the sails will be launched by rocket into high Earth orbit, where they will unfurl. Source: U.S International Space Year Association... .*

Let's narrow the field to the mystique of information and its conveyance through multimedia.

Electronic City Hall - You will register to vote, sign up for racketball, and lodge a complaint with the mayor, at an electronic kiosk. Currently, in Mercer Island, Washington, an electronic information booth, called "The 24-Hour City Hall," has been set up near a grocery store to give citizens 24-hour access to their municipal government. Developed by Public Technology, Inc. (PTI), it uses an IBM microcomputer and multimedia technology to give information on town meetings and local government services. More electronic city halls are being set up in other U. S. communities. (*The Futurist*, September-October 1990, p.6)

Computer with "Brain Waves" - an IBM scientist and colleagues at Columbia University designed a supercomputer model for studying the area of the brain called the hippocampus, an area associated

with epilepsy. The model unexpectedly began producing its own electrical waves, surprisingly similar to the brain waves of the hippocampus. If this is an accurate simulation, "experiments can be done on the model as if it were an organism in its own right." (*The Futurist*, September-October 1990, p.6)

From the magazine *Verbum*,* Winter 90/91:

• Mind Ware - MC^2 and MindsEye Synergizer (for the IBM). Light & Sound Research, Pasadena, CA and Synectic Systems, Seattle, WA. *These are two brain-wave controllers, with a combination of special glasses and earphones that deliver strobe lights and sounds to entrain users' brain rhythms. The machines are based on the same research that associated different brain waves with various states of consciousness. Each can induce either the alpha state for quick relaxation or a body-relaxed but brain-alert theta state for enhanced learning via cassette tape. MC^2 by Light & Sound Research provides a microchip with ten preset light/sound combinations built into a controller box that its goggles and earphones hook into. It does not link with a personal computer system and is not user programmable. Synectic Systems' MindsEye Synergizer provides a PC board that fits into a slot on an IBM PC/AT/XT/386 or compatible, along with goggles, headphones and software. The specific light/sound combinations are programmable by the user. In fact, each eye and ear may be programmed independently. A separate kit lets developers program applications in the C language.* (Verbum, p.44)

• Video - DigiVideo (for the Mac). Aapps Corp., Sunnyvale, CA. *This color real-time video board allow the user to display and capture 24-bit images for actual computer processing, whether in teleconferencing or multimedia applications. The board includes an improved tuner and supports 98 channels. It can also display in black and white mode using 128 gray levels. Also contained in the package is Prefaced Publisher's Exposure, a color image grabber and color paint CDEV.* (Verbum, p.47)

• HyperMedia - ADDmotion (for the Mac). Motion Works, Vancouver, BC, Canada. *ADDmotion adds modules to HyperCard 2.0 that allow users to create animated sequences. The software lets you edit and create full-color pictures, animate them and add four-track sound. Object-oriented and interactive animation allow flexible animation production. Cues in ADDmotion are passed back to HyperCard, providing complete interaction with the HyperTalk programming language.* (Verbum, p.42)

• Verbumalia: Cool Stuff To Order - Verbum Interactive. *The first edition of the Verbum CD-ROM. Requires Macintosh II with 5 MB RAM and CD-ROM drive. Incredible interactive magazine in color and sound with a Gallery of animation and multimedia works . . . software demos, interactive articles, and much more! $49.95* (Verbum, p.60) The demo programs are in part advertisers in the magazine. A two-disc set in interactive format. The music on the discs will also play on a regular audio CD player.

In addition to some "brave new world" technologies I have tried to give a small panoply of what's going on in the new world of multimedia - and have barely scratched the surface. Not touched here are multimedia technologies such as Microsoft's Windows and its extensions, enduser-level authoring systems from

*Verbum 4.3, *Journal of Personal Computer Aesthetics*, Winter 90/91. "This is the magazine that helped spawn a revolution in the world of personal computers by proposing that the creative spirit could work its magic through silicon, that the human hand and mind could use digital media in the making of True Art." (Issue cover)

MacroMind, Authorware, and other companies, and IBM's magnificent educational interactive multimedia projects "Ulysses" and "Columbus."

AN UNDERSTANDING OF THE ROLE OF MULTIMEDIA IN SCIENTIFIC AND TECHNICAL INFORMATION

Multimedia is not an end in itself. Its role is apparent in *Grand Challenges: High Performance Computing and Communications*, a report issued in 1990 by a committee supported by the National Science Foundation [CPME90]. According to the committee, challenges facing the United States concern high performance computing systems, advanced software technology and algorithms, the creation of a National Research and Education Network (NREN), and basic research and human resources. These are the four major components of the *Grand Challenges* program. They in turn break down further into more specific areas to be researched and developed.

Multimedia is a result of and will be effected by the outcome of research and development in all four of the program components. The very basic purposes of the high performance computing program will be creation of advanced technologies for the collection and storing of information, the accessing and transmission of the information, the availability of computer resources (both local and remote) to process and re-process the information, and the collection and storage of tailored information locally to fill the needs of the local user. The information will be constituted in all its possible varieties -- text, numeric, graphic, sensory.

Multimedia means no longer asking for paper or file output of text and numeric data. Multimedia means building an information base that suits its user. The base will be comprised of scanned information. If it includes text, the text will be images of the print material, and will be textually searchable, *i.e.*, *hypertext* searchable. But the base will be comprised basically of images relevant to the user's information need. The images will be both static and motion, *via* animation and video. The base is further supported by sound -- vocal, noise, and musical; and graphics programs will present, process, and enhance the information; graphics in itself is an expansive and distinct universe of computer processing.

It is thus foreseen that a user's primary source of working information will be the multimedia system information base that the user creates to serve his needs. This will be a local system; information and computing resources may be accessed remotely, but such activity will be subsidiary in a supporting capacity to the local multimedia base.

The NASA Scientific and Technical Information Program (STIP) sees the need for incorporating new technologies into the handling of STI. As stated by the Program's Director in the STIP strategic plan (STIP91), "As we approach the year 2000, there are many exciting opportunities for revolutionizing the way STI is managed, thereby increasing its value to NASA, the U.S., and our international partners."

In summary, I would like to paraphrase an earlier paper [KUHN89]: The NASA Scientific and Technical Information Program is at the threshold of its entry into multimedia. Because the business of STIP is information, there is a vast opportunity for looking at multimedia applications, assessing their relevance to the handling and processing of scientific and technical information in the NASA research and development community, and developing multimedia implementations for doing so.

As NASA STIP explores this area more intensively, we find an increasing critical

requirement to coordinate and interface all STIP multimedia development to assist the NASA user in the quest for information. Multimedia in all its forms is establishing the contextual handling of user-selected, user-relevant information. Contextual handling of information, regardless of its source and form, and approximating the human manner of handling information, is the reason for implementing multimedia systems.

In doing this paper on the subject of multimedia, though, note an irony -- it's paper, it's without graphics, it's teletype-style sequential. Yet this is the verge of the 21st Century. All the capabilities of multimedia expressed in this paper are present today.

All we need to do is to make the jump, and today that's hardly a large one.

§ § §

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CAVEAT

The mentioning of companies and products in this paper is by no means an endorsement. The companies and products noted simply serve to illustrate pragmatically the many multimedia programs and systems in use in private industry.

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This paper relates the concept of computer-driven multimedia to the NASA Scientific and Technical Information Program (STIP). Multimedia is defined here as computer integration and output of text, animation, audio, video, and graphics. Multimedia is the stage of computer-based information that allows access to experience. This paper also draws in the concepts of hypermedia, intermedia, interactive multimedia, hypertext, imaging, cyberspace, and virtual reality. Examples of these technology developments are given for NASA, private industry, and academia. Examples of concurrent technology developments and implementations are given to show how these technologies, along with multimedia, have put us at the threshold of the 21st century. The STI Program sees multimedia as an opportunity for revolutionizing the way STI is managed.

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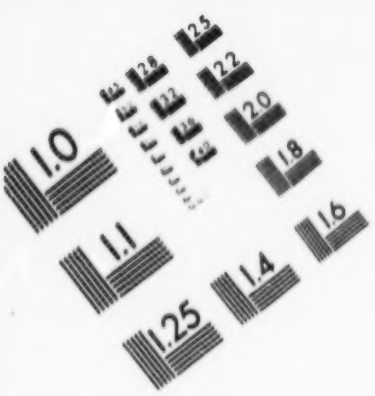

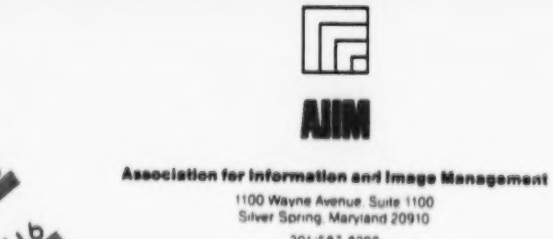

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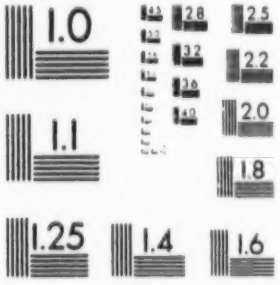

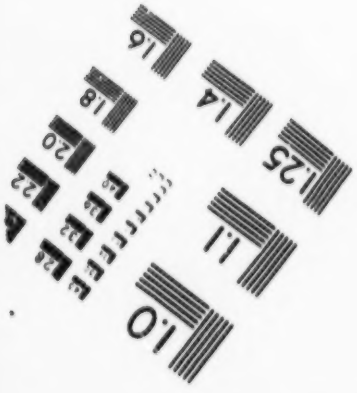

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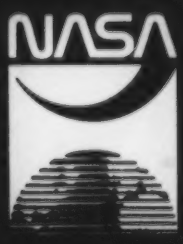

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